Patterns in Plant Leaf Flammability of Woodlands and Forests of Eastern Australia

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Certificate of Original Authorship

I, Daniel Krix declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Life Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by an Australian Government Research Training Program.

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List of Abbreviations in this Thesis

Context	Abbreviation	Definition
Flammability attributes	TTS	Time to smoke
	SD	Smoking duration
	TTI	Time to incandescence (equivalent to time to ignition used in Chapter 2)
	ID (BD)	Incandescence duration (equivalent to burn duration used in Chapter 2)
	TTF	Time to flaming
	FD	Flaming duration
	MLR	Mass loss rate
Leaf traits	LA	Leaf area
	LMA	Leaf mass per area
	LWC	Leaf water content
	FMC	Fuel moisture content
	FLM	Fresh leaf mass
	DLM	Dry leaf mass
Miscellaneous	PGLS	Phylogenetic generalised least squares
	OU	Ornstein-Uhlenbeck
	WUI	Wildland-urban interface
	OLFI	Overall leaf flammability index
	MPD	Mean pairwise distance
	FM	Full model

REM	Radiant energy model
LFM	Leaf flaming model

Abstract

Exacerbated by global change, wildfires are causing unprecedented impacts on ecosystems, human lives and infrastructure. Thus, there is a pressing need to better understand the drivers of wildfire in this changing world. I investigated interspecific patterns in plant leaf flammability in fire-prone vegetation of eastern Australia to determine the flammability dynamics of leaves given their essential role as fuels for wildfires.

At a landscape scale, I found that leaves of forest gully species had faster ignitibility and higher combustibility relative to woodland ridgetop species. These differences were driven by strong relationships between high flammability and both large leaf area and low leaf mass per area. For these plant communities, I explored relationships among leaf ignitibility, sustainability and combustibility and showed that faster ignitibility (higher flammability) was associated with short sustainability (lower flammability), and long sustainability (higher flammability) with higher combustibility (high flammability). Given the opposing relationship between ignitibility and sustainability, I established an overall leaf flammability index to assist in identifying low-leaf-flammability species at the wildland-urban interface. Close inspection of the flammability of ten species showed that increasing radiant energy, representing increases from low to moderate intensity wildfires, led to faster ignitability and a higher proportion of leaves flaming, such that species identity became much less important for understanding flammability dynamics. However, species identity remained particularly important for leaf sustainability and time to flaming, signalling that species differences in these flammability attributes may be helpful in understanding the dynamics of moderate intensity wildfires. Finally, I built predictive models of leaf ignitibility, sustainability and combustibility using a combination of radiant energy and leaf area, mass per area, and water content, and tested the accuracy of the models using a validation

dataset. Including leaf traits in these models dramatically increased the ability to predict leaf flammability. One application of these models will be to estimate leaf flammability for large numbers of plant species using just their leaf traits, without the need for flammability experiments if they are not feasible.

This thesis provides novel insight into interspecific variation in plant leaf flammability. The findings of my research advance our ecological understanding of leaf flammability, with potential applications to wildfire modelling, the selection of low-leaf-flammability species at the wildland-urban interface, and prediction of leaf flammability for large numbers of species using leaf traits.